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RESEARCH AND DEVELOPMENT IN MICROELECTRONICS IN ARGENTINA, BRAZIL, MEXICO AND VENEZUELA

prepared by

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CONTENTS

	Page
Preface	1 - 3
Research and Development in Microelectronics in Argentina	4 - 9
Research and Development in Microelectronics in Brazil	10 - 16
Research and Development in Microelectronics in Mexico	17 - 22
Research and Development of Microelectronics in Venezuela	23 - 30
Regional Cooperation in Research and Development in Microelectronics	31 - 33

PREFACE

In the four countries that have been analyzed there is a clear understanding of the important role that research and development could play in the future of the electronic industry and in particular in the future of microelectronics. It is recognized that microelectronics is an industrial field of high risk where local research and development capacity is needed even to be able to use foreign technology properly; such a capacity is even more necessary if the intention is to develop local technology not available from foreign sources in adequate conditions, for instance, when the intention is to manufacture strategic products for the internal market or for exports.

Training and development of specialized human resources is considered as a key element for the research and development strategy in this field. The support of higher learning institutions and universities that could contribute to form these human resources is also a very important point within the overall R&D strategy.

Considering the fast evolution of this industry, maximum interaction between production and research is an important objective in all these four countries. They have explored several ways to facilitate collaboration between research groups and industry and even to promote the establishment of research groups within industries themselves.

In all these countries there is a clear understanding of the important role that could be played by researchers as entrepreneurs and innovation promoters in industry. This is possible because their

knowledge gives them control over specific technologies, very valuable for existing enterprises or as a basis to start new high technology ventures. This movement of specialists seems to be a very good way to transfer technology between research groups and industry and to give them basis for long-term collaboration.

In the four countries there are effective means to finance research projects with medium-term objectives through governmental organizations responsible for the promotion of research and technological development, and also to provide funds for innovations promoted by industry, with high risks but with possible benefits in the short-term, through specific financial bodies.

The R&D infrastructure in the four countries is characterized by several common elements: the existence of electronic development groups in research institutes focused into specific sectors, like: telecommunications, oil, electricity, etc.; microelectronics development groups located in universities and higher learning institutions; and research and development activities with different levels of maturity in the most dynamic electronic companies. There are also some significant differences among them, such as the fact that Brazil has already an Informatic Technology Center (Centro de Tecnología Informática) that has, among others, a Microelectronic Research Institute that gives to this country a specialized infrastructure with and excellent scientific and technological capacity and a special industrial orientation that is not very common in other countries of Latin America.

The National Center for Research in Electronic Components (CENICE) of Argentina, is also designed to work within a national perspective in a long-term framework and with industrial orientation. It is therefore on the same lines as the Microelectronics Research Institute of Brazil, even though it has had fewer resources available. CENICE is within the general scheme of the Technological Research Center of the Armed Forces (CITEFA), has a very important technical

infrastructure and well defined plans focused into industry. Venezuela and Mexico do not have yet this type of research institutions devoted specifically to microelectronics research with an industrial focus. In Venezuela, the "Fundación Instituto de Ingeniería" has already a group with the technical capacity to undertake these functions. A specialized center to provide technical support to the electronic industry is being organized in Mexico under the sponsorship of the Government and industry.

In relation to national plans and policies to promote research and development in microelectronics, the four countries have great interest and different levels of definition. Without any doubt, Brazil has a better definition in its plans, programs and policies and good ways to implement them through a very wide political and institutional support and adequate infrastructure for research, development, training, services and coordination with industry. Argentina is working at high speed with similar objectives and has already important results in reference to: diagnosis of the present situation; legal and institutional mechanisms to define programs and projects with industry; specific plans to strenghten the R&D infrastructure in microelectronics, including that associated to human resource development; and a very precise definition of national objectives in this field.

In Venezuela and Mexico there is also a tendency for a better definition of plans and policies to promote microelectronics, both in the industrial aspects and also in those of R&D. The First Symposium on Electronics held in Venezuela in late 1984 with the support of several government departments, industry, universities and research institutes, set the basis for a national policy with long-term objectives in this field. In Mexico there are many activities within different governmental organizations and also within industry and research groups, that very likely will merge in a short time in a national policy in this subject.

Summing up, it could be concluded that in these four countries there is a strong basis to promote a very fast development of R&D in microelectronics.

RESEARCH AND DEVELOPMENT IN MICROELECTRONICS IN ARGENTINA

Argentina is a country with a very important scientific and technological infrastructure, with a very high level of education and with a great potential to develop and industrialize technological advances in microelectronics. In the last ten years Argentina has been through a process locally called "desindustrialización" by which many companies have closed or were bought by foreign companies. The latest industrial policy is changing this, and is giving special attention to sectors like informatics, telecommunications, microelectronics and electronics in general, because they are very dynamic and because they can be integrated to a national strategy to improve the efficiency of the productive sector, stimulating at the same time exports, imports substitution and the country's technological development.

Since the 60s there were several activities started in microelectronics in Argentina. By 1974 there was already some work done in the development of silicon planar transistors in the microelectronics group of CITEFA (Centro de Investigación Tecnológica de las Fuerzas Armadas). This group was later integrated to the new CENICE (Centro Nacional de Investigación en Componentes Electrónicas) when this was created in 1977. This new center had the support of government institutions that represent the sectors of science and technology, industry and defense. CENICE has become an organization capable to produce special devices, such as hybrid circuits of high quality, and able also to advise industry and government in relation to the design and fabrication of microelectronic components, as well as to undertake directly testing and technological development activities in this field.

Within the Argentine Government, the "Secretaría de Ciencia y Técnica" is responsible to coördinate the National Program in Electronics, established more than ten years ago. This program

has channeled different kind of support to research groups, giving them guidance to work within national priorities and avoiding unnecessary duplications.

There are several groups undertaking R&D activities in microelectronics, most of them within universities and research centers. We can mention here the universities of: Buenos Aires, La Plata, El Litoral, Córdoba, Tucumán, Cuyo, Del Sur. and institutions like INTI (Instituto Nacional de Tecnología Industrial), the Bariloche Atomic Center, the National Telecommunications Laboratories (LANTEL), CENICE and other groups form CITEFA.

It is estimated that in all these groups there are more than 1000 professionals -most of them electronic engineers- including researchers, support personnel and trainees in different areas of development or applications of microelectronics, not including those working in software development.

As was mentioned in the Preface, Argentina shows a high degree of maturity in the definition of a national policy in microelectronics. The report of the "Comisión Nacional de Informática" dated October 1984, in its preliminary version for discussion, shows a clear description of the National Strategic Project in this field, that reflects the importance the Argentine Government is giving to the integrated field of informatics, telecommunications and electronics, pointing out also toward specific actions in relation to industry, technology, law and training, to promote the development in this field.

The "Comisión Nacional de Informática" was created under the new government, with participation of the "Secretarios" of: Science and Technology, Industry, Communications and Public Function. This Commission is therefore at the highest governmental level, corresponding to the importance given to this field. The Commission's report gives a very special role to R&D; it very clearly

states that the technological capacity of industry, added to that of the research institutes that support them, determines the ability to compete and the potential for growth of industry.

The need to acquire and assimilate technologies from other countries is recognized, given that the assimilation is done fully and with the support of R&D activities closely linked with the industrial practice. The importance of adequate training and proper orientation to human resources development programs for this field is fully recognized, starting with good engineering and science schools, and considering that the personnel that participate in research and development are actually obtaining an advanced level of training as well.

The Commission's report underlines some characteristics of microelectronics technology that make it specially interesting for a country like Argentina. It shows, for example, that it is a technology that has been widely spread and that is also relatively accessible. The advances in large scale integrated circuits design tools and manufacturing processes, for instance, could be acquired internationally, at least most of them, from several suppliers that are competing among themselves. National markets present big opportunities for local industry if competitive developments are achieved and with adequate technological capacity industry they could also have access to "niches" of the world market.

It is also recognized that industries associated with microelectronics have high risk and live with technological barriers that constitute the main problem to achieve independence of action and improve local development. Therefore, local technological development has a big priority to allow companies to brake barriers, to diminish risks and to follow their own strategies. It is also noted that there is a special phenomenon in the sector associated to the difficulties to protect research results that could be transferred by

specialists of research groups to industry. It is mentioned that researchers frequently move out to start their own industries or to participate in other industries, generally new, in which they play a very important role. This leads to the conclusion that it is a government responsibility to promote the development of research infrastructure in this field, and assume that it is a natural process that some researchers will move with key knowledge out to industry.

In reference to industrial development, the report indicates the need to strenghten an industry that should be innovative, independent and competitive, because this kind of industry has the mechanism to assimilate and develop local technology. Some technological criteria are also given to identify areas in which industrial opportunities could be found: accessible technology, efficient for the levels of production than could be attained locally, intensive in local technology, with foreign technological inputs that could become accessible, related to flexible processes, not requiring large investments and allowing local subcontracting of components with maximum national integration.

With reference to research and development, it is proposed to invest 5% of sales and to promote collaboration among enterprises and research groups. It is also recommended to take advantage of the research capacity to offer specialized technical services, such as: standardization, homologation, quality control, tests, specialized advise, technical support for the acquisition of materials and equipment, support to the disaggregation of systems, technology transfer information services and follow-up national trends in this field.

Another important recommendation is to review the evaluation criteria of CONICET researchers. It is claimed that the evaluation mechanisms that have been followed in the past do not agree

with the characteristics of technological research, because they are based on those of basic sciences. It is also noted that under the "technological domain", the originality concept should not be applied in traditional absolute sense, but considering that in many cases it might be necessary to produce knowledge locally, that is already available for other countries, and not available for Argentina, as it is the case in some microelectronic processes. It is recommended to consider in the evaluation of researchers, the applicability of their results and their work in supporting technology transfer, that sometimes is taken as routine engineering that "waste research resources".

In reference to the training of technicians and specialists, it is recognized that the achievement of high professional and technical qualifications has a great importance, and therefore it is needed to promote the training of teachers in the research environment where they can also be in touch with the world network in which the new concepts are being developed. It is considered that in this way teachers will be able to transfer the spirit of research that students require.

It is proposed that the promotion of new developments should include areas within the following subsectors: Data-processing equipments; telecommunications, electronic equipment for offices; industrial electronics (process control, electro-medicine, automatic instrumentation, robotics) and electronic components. Special mention is made about the importance of software development, starting with the training of specialists and the development of software developments tools. In microelectronics it is proposed to create new capacity for the design of custom and semi-custom circuits, in order to take advantage of the facilities of silicon foundries that could be subcontracted elsewhere. In the subprogram of microelectronics and components, the National Electronics Program makes the following proposals:

1. To recommend scientific and technological research activities in amorphus, polychrystalline and single-chrystal silicon, with the purpose to conceptualize design and manufacture highly reliable integrated circuits.

2. To ensure the capacity to develop MOS integrated circuits of specific design, without endangering the support to the study and manufacturing of other types of integrated circuits.

3. To recommend scientific-technological research in semiconductors complementary of those made out of silicon to develop devices of different complexities and the R&D related to their applications in electronics, opto-electronics, detectors, microwaves, etc.

4. To develop electronic component technologies that could complement activities referred in items 1, 2, and 3, such as: capacitors, thin-film registors, small-size energy sources, insulated ceramics, monolitic ceramic filters, etc.

5. To develop the technologies related to the systems that use the components mentioned before.

6. To maintain adequate capacity to study basic problems related to the subjects that have been already indicated.

With this brief description of what is happening in microelectronics in Argentina, it could be said that this country is considering it as a priority area within its industrial development strategies. There is no doubt that in the next few years Argentina will have important advances in this field, with big effects on regional cooperation in microelectronics.

RESEARCH AND DEVELOPMENT IN MICROELECTRONICS IN BRAZIL

Brazil's strategy for research and development in microelectronics is based on the recognition of the importance of this field as a way to facilitate competitiveness and innovation capacity in the different branches of electronics.

It is considered that this capacity, specially in reference to the design and fabrication of printed, hybrid and integrated circuits of different levels of complexity and also of other electronic components, is the most important element to insure the competitiveness of electronic industry.

Microelectronics is obtaining a very strong support within the informatics strategy of the country; the microelectronics program was elaborated with the support ot the "Secretaría de Estado para la Informática" (SEI) working in coordination with TELEBRAS, FINEP and other organizations. The Microelectronics Institute is a part of the Center for Informatics Technology, that has been created recently. Because all of this, it is necessary to start analyzing Brazil's policy and plans in informatics to understand the framework for its development in microelectronics.

After the establishment in 1976 of the National Policy of Informatics (PNI) Brazil has had means to formulate a long-term program for R&D in this field very closely linked with the development objectives of the country.

The "Secretaría de Estado para la Informática" (SEI), created in 1979, organized a series of measures to promote research and development demands related to hardware, software, components and peripherals, as well as to the applications of informatics.

Brazil's research and development infrastructure in this field is very broad. It includes very strong research groups in universities

like those of Sao Paulo and Campinhas and also in research institutes focused to specific sectors like petroleum, electricity, aeronautics, etc. In most of these groups there has been important advances in informatics, specially in software development for specific applications.

The Brazilian industry has responded very favorably to the national policy of informatics, developing products with their own technology and covering more than 45% of the market with products that have very high level of national integration: 95% for the central unit, the keyboard and the monitor in micro-computers, for example, or, as in the case of the Cobra 500 mini-computers, that is reaching 97% in machines totally designed in Brazil.

A fundamental premise of Brazil's National Program in Informatics is to ensure that local industry develops its own technical capacity, using what is called the "market reserve mechanism to create conditions to develop national technology". Industry is requested to operate with its own technology, The agreements to use foreign technology must be for a limited time and with the assurance that they will be used to develop local capacity.

The results have been very impressive. The development of their own technology has allowed companies to cover the continuosly growing segment of the market products that are internationally competitive, generating an increasing number of new employments (110% more than the multi-nationals for 1983) not only for workers, but also for engineers and researchers; to increase national integration levels above 90% and to provide bases for the export of informatics products. Brazil's previous experience in the aeronautics and war material industries shows that technological autonomy is a pre-requisite to export products in high technology sectors like informatics.

Brazil's informatics policy has often been under attack under the supposition that it is leaving the country with "third quality" technologies. The truth is different. In reference to microcomputers hardware, Brazil equipments are using the most advanced integrated circuits and are side by side with those of other countries, mainly because of the R&D work done locally. Brazil's peripherals have been lagging behind mainly because of technological weakness in precision mechanics, but they have now been superated by the new models for printers, disc drives and others. In relation to software, Brazil has more than 83,000 professionals working in its development, even for the so-called "basic" software, like operating systems and compilers, that has been developed by groups within the universities.

Industry's R&D activities in informatics, as well of those from the universities and from sectorial institutes in this field, will be supported by the new Informatics Technology Center (CTI) through its Computation Institute, that will be working in areas like basic software, specifically in: compilers, operating systems, editors, tools for facilitating and automating software development, etc.

The Computation Institute will also work in the following areas: to develop interphases to link Brazilian peripherals with large foreign machines; support to software development for specific sectors, like medicine; to develop standards and certification mechanisms for programs and equipment; it will certify,from a technical point of view, industries' integration plans and will help to identify and take advantage of new opportunities to increase integration and start the manufacturing of new products. It will help also in the analysis of import permits and through new specialized laboratories will also be able to study different phenomena related to the life and performance of equipment such as: tolerance to varying electrical supply conditions; electromagnetic interference; the life of components, boards and complete equipments.

Besides, the Microelectronic Institute that will be described later on, the Informatics Technology Center has also two other institutes in the areas of automation and instrumentation. The Automation Institute has three departments: Process Control, Manufacturing Automation and Advanced Engineering; it is undertaking projects within industry, like, for example: Control systems for aluminum furnaces; CAD-CAM system with manufacturing companies and is also developing distributed control systems. The Instrumentation Institute has also three groups: sensors and actuators; instrument maintenance (medical instruments for hospitals, mainly); and standards. This Institute is working in the development, for example, of certification procedures (that later on it will transfer to other institutes). It is collaborating with the National Metrological Institute and with the Underwriters Laboratories in the United States to certify exports; it is also collaborating with industry in the design and installation of measuring systems for quality control, for example, of printed boards; among other functions to support the manufacturing of components and devices, it is working with the SEI in studies to promote import substitution, for example, of step motors that are used in peripherals, of special materials and others.

The Informatics Technology Center works very closely with industry to promote the manufacturing of products that will substitute imports, and to adapt them to the needs, the materials and the manufacturing capabilities of the country.

Companies that are users of electronic equipment in Brazil like TELEBRAS and also manufacturers of this kind of equipment like the ITAU Group, are organizing design groups for integrated circuits, in some cases. They also have capacity to manufacture them. This is a sample of the advanced technological level of many industries in this country and also of the scientific and technological demand that has been generated in this field.

There are other industries like AEGIS and HELIODINAMICA, manufacturing power diodes and solar cells respectively, with locally developed semiconductor technologies, that are an example of the excellent interaction that has been achieved between research groups and industry.

Many of these results are based on the research and development work started more than 15 years ago in universities like those of Sao Paulo and Campinhas. It is also found that many of the promoters of the new companies, the technical leaders of the industrial groups and the heads of the new research institutes were formed within the research centers of the universities. All of this shows many of the benefits that came out from the important and continued support that has been given to scientific and technological research in microelectronics in Brazil for more than a decade.

The recent establishment of the Microelectronics Institute, within the Informatics Technologies Center and under the broad umbrella of the Brazilian Informatics Policy (PBI), provides stronger basis for R&D activities. The new market for informatic equipment opened by the PBI is widening the demand for microelectronics and also promoting research and development to fulfill this demand. The solid infrastructure of the Microelectronics Institute will allow important advances in the design and in the manufacturing technologies for integrated circuits and has became a strong support for other research groups that could use this powerfull infrastructure, through consultancy and technical services, to develop their own prototypes.

The microelectronics research and development program of Brazil was established under the promotion of a high level group intergrated by the "Secretaría de Estado para la Informática" (SEI) TELEBRAS and FINEP (Finance Fund for Research Projects). To elaborate this program, a Technical Consultative Council, chaired

by the Director of the Microelectronics Institute, was established with the participation of selected specialists. The program defines objectives and priorities for R&D projects. With this basis the research centers could find an orientation to develop their own infrastructure and to submit proposals for projects that besides being relevant could be coordinated and complemented with those that are being realized by other institutions.

There is no doubt that Brazil has already the instruments, the policies and the demand to go on with a very ambitious research and development program in microelectronics. Two of the main objectives of the program are to ensure that the country will have the minimum capacity required to be independent from foreign suppliers of strategics materials and components and to maximize the competitiveness of Brazil industries in this field.

Some of the areas with high priority within the program are the following:

1. Capacity to design integrated circuits, considering semi and full custom; design strategies and techniques; design for testability; design tools including lay-out testing and simulation; models of devices.

2. Scientific and technological capacity required for manufacturing process of integrated circuits, including: preparation of substrates and their physical properties; thermal oxidation; thermal deposit of dopants; ionic implantation; standardization or nitrates; masks; lithography; materials corrosion; chemical cleaning processes; encapsulation process equipment; methods and devices for the characterization of processes; models for processes; etc.

3. Applications for new materials; processes and new structures in microelectronics.

4. Basic inputs for microelectronics; semi-conductor materials; chemical products; photolithography and encapsulating materials; metals; gases, etc.

5. Measuring techniques for microelectronics; characterization of materials for sustrates and conducting films; characterization of different process stages and devices; integrated circuit characteristics; electrical testing, etc.

This research and development program is based on the coordination between industry, research groups, universities and the different government organizations related with this field. This coordination is essential to ensure that research is well oriented, with adequate governmental support and contributing to the training of specialists, that is one of the highest priorities of Brazil's technological policy in microelectronics.

To promote the training of scientists, engineers and technicians, strong support is given to technical schools and universities, including resources for infrastructure and better salaries for researchers. This is done by the financing of projects selected because of its quality and relevance. This financing gives extra salaries, amounting up to 50%, to the researchers, ensuring, on the other hand, that they have adequate working conditions.

It can be added, as a short synthesis that Brazil's program for R&D in microelectronics has very important innovations that could guide and inspire activities of the same type in other countries.

RESEARCH AND DEVELOPMENT IN MICROELECTRONICS IN MEXICO

The National Program for Scientific and Technological Development in Mexico gives special priority to electronics, mainly because of its importance in the structural change that is intended for Mexican industry. Given that electronics is an activity based on advanced technology, high priority is placed to research, development, training and technical services activities that will support it. The National Council for Science and Technology has an electronics program through which resources are channeled to support infrastructure for research institutions and to finance specific projects.

In other areas of Government there is also special attention to electronics and the associated research and development activities. The Ministry of Communications and Transport is promoting research activities in telecommunications and is also creating a national institute in this field. This institute will give a broader scope to the work that has been undertaken by the former Research and Development Center in Telecommunications (CIDET) that has been operating within the Ministry. This new Institute, created as an independent organization, will have greater operational flexibility, better conditions to integrate, develop and keep high level personnel, and better support to focus their work on the medium-range needs of the country. This same Ministry is also promoting research and development activities within universities and telecommunications industries through its recently created General Direction for Research and Technological Development. R&D has been oriented to the National Telecommunications Program priorities, and includes : the modernization and broadening of the federal microwave network; satellite communications and digitalized telephonic networks as well as its integral

use for voice, video data transmission and improvements in radiomaritime communications, among other subjects.

The Ministry of Commerce and Industrial Development is responsible for the electronic industry manufacturing program and has given special attention to the subsector of computers and peripherals. Before 1981, most of this equipment was imported. Between 1981 and 1983, 42 programs to manufacture locally were approved, from which 20 were related to microcomputers, 12 for mini-computers, 17 for peripheral equipment and 4 for control systems. To date there are nearly 80 programs registered. The Ministry is promoting R&D activities of these companies by asking them explicity to devote at least 5% of their sales to this kind of work; priority is been given to projects that are contracted with independent research institutions with the purpose to multiply and strenghten the national technological capacity in this field.

The Ministry of Energy, Mines and State Industry is giving special importance to electronics as a way to promote the acceleration of technological change and the modernization of many of the industries belonging to this sector. It considers electronics also as an essential area in which it is possible to use the buying power of the State, and the research and development capacity of the sector, to promote electronic enterprises that could become internationally competitive and could have also a very important effect in the local manufacturing of materials and components. The "Centro de Evaluación de Proyectos" (Projects Evaluation Center) in this Ministry, prepared recently a report that presents a global diagnosis of this field and gives special recommendations for a general plan of action that gives special importance to the scientifical and technical infrastructure related to this field. In particular it is clearly stated that: " The materialization of

the objectives that have been stated depends, in a fundamental way, on a big and well organized effort in the areas of research and development, training and human resources".

The Ministry is basing its program on the activities of the research institute within its area of competence, such as those in oil, electricity, steel and nuclear research. The electronic activities of these institutes are focused mainly on specific applications and there are also some activities to develop electronic circuits design tools and to provide technical support to the manufacturing of circuits and equipments. This Ministry has also proposed the possibility to organize a new center for research and technical services in electronics that could start with technical services to the electronic industry and could be established with the cooperation of industry and the professional community in electronics.

In the past, electronic research undertaken by universities and technical schools has been, according to the National Council for Science and Technology, "Undertaken without proper order and without precise industrial objectives", "it is not difficult to find appearance and disappearance of research lines because many of them have been sustained on the basis of personalities and not on true master plans that will determine clear priorities and strong institutional commitments", "a proper level of technology transfer has not been achieved yet between the research made in specialized educational institutions and the sector that produces goods and services".

This situation is bound to change, specially in independent research institutions where more than 20 new electronic products have been successfully transferred to several industries.

Some of the most important R&D groups in electronics are the following :

In telecommunications there is the strong participation of the Center for Research and Advances Studies (CINVESTAV) with its Electrical Engineering Department (Rural telephonic exchanges, manual and automatic, modem testers, microwave networks for telemeasuring, supervision and linkage). The Metropolitan Autonomous University (UAM) with private - telephone exchanges, automated telegraphic exchanges .

The National Autonomous University through its Engineering Faculty (speech recognition systems and devices, modems,etc.).

The Scientific Research and Higher Education Center in Ensenada (CICESE) (Radio telephony, network planning, digital commutation for rural areas). The Research and Development Center in Telecommunications (CIDET) (metrology, standardization homologation, microwaves and data transmission systems and equipments). The Telephone Company (TELMEX) research group (automatic digital exchanges, fault detection, long-distance call... meters, alarm detectors).

The Electrical Research Institute (IIE) (remote-terminal units, fiber optics, carrier,microwave networks . INDETELEC (telephone exchanges, telephones, digital radio systems for rural telephony, microwave equipments). Some small private industries in the area (modems and telephone exchanges). .

In instrumentation, there is also work being done through the Instrument Center of the National Autonomous University (UNAM) (power supplies, test and measuring equipment) the National Institute for Nuclear Research (measuring equipment), and the Petroleum Institute (IMP) (measuring equipment), among others.

Process control research has been performed by the UAM (adaptive control); the "Escuela Superior de Ingeniería Mecánica y Eléctrica" (ESIME) (data acquisition system); the National Autonomous University (UNAM) (systems for the control of water supply networks); the "Instituto Tecnológico y de Estudios Superiores de Monterrey" (ITESM) (digital process control systems); the Regional Technological Institute of Tlalnepantla (numerical control of machines and machine tools), the Electrical Engineering Department of the CINVESTAV (fermentation systems control); the IIE (programmable controlers, sequence controlers, electronic equipment for instrumentation and control systems); the IMP (process control systems and equipment).

There are also several groups working in biomedical equipment, mainly at the CINVESTAV, the Social Security Institute, the Cardiology Center, the Medicine School and the Mechanical and Electrical Engineering School of the National Polytechnic Institute (IPN) and the Iztacala unit of the UNAM.
There are three important groups working in semiconductors. The Electrical Engineering Department of the CINVESTAV; the National Institute of Astrophysics , Optics and Electronics and Puebla's Autonomous University. The first two are working on the fundamental processes to design and manufacture discrete power devices and MOS integrated circuits of low complexity, starting from the wafers; in the third group R&D activities started with the development of laboratory equipment necessary to experiment the fundamental processes of this technology (high temperature furnaces, testing machines, temperature controllers, equipment, etc.). Also the Physics and Materials Institute of the UNAM are working on monocrystaline silicon and amorphous silicon respectively, and they have plans to broader their capacity related to materials and components for microelectronics.

In informatics there are also groups developing new products in industry (MEXEL, Micrológica Aplicada, Transdata and Link, among others) and in research institutes like the Electrical Engineering Department of the CINVESTAV, several institutes within the UNAM (Research Institute on Applied Mathematics, Systems and Services, Instrumentation Center, University Program for Computers); the Electrical Research Institute (IIE), and in the Mexican Petroleum Institute (IMP), among others.

Practically all the groups that have been reported, have been working in the past with institutions of other latin-american countries, specially at the level of technical visits, inform - ation exchanges and participation in regional meetings.

In microelectronics it is appreciated that there is little interaction between research and industry. This is due principally to the incipient industrial development in this field and also to the fact that design and development groups working with equipment and devices have not been interested so far in more intense utilization of custom and semi-custom integrated circuits. There is already a big interest in the possibility of establishing a center to provide technical support to the electronic industry for electronic circuits design, interaction with silicon foundries and in general for the development and evaluation of electronic equipment. This center could also improve the collaboration between industry and research institutions, facilitating the industrial application of research results and also the identification of opportunities for new projects.

RESEARCH AND DEVELOPMENT OF MICROELECTRONICS IN VENEZUELA

The Government in Venezuela has announced that the subsector of electronics, telecommunications and informatics has been included as one of the priority aspects of the VII Plan of the Nation. It is considered as a catalyser element for the scientific and technological progress that should follow the autodetermined integral development that the country is looking for.

In the I Symposium of Electronics that was held in Caracas in November 1984, it was concluded among other things, that :

- There exist several good conditions for the development of electronics technologies through innovative national enterprises that have arisen after 1974, and that are designing, fabricating and commercializing to the point that have already achieved significant levels of sales in the country. It is recognized that these companies have been favored by factors such as:

  . Availability of highly qualified engineers.
  . Advantages of having the capacity to design according to the needs of the local markets; to give better service and maintenance and to compete in quality and price with foreign products.
  . Availability of risk capital and ,
  . Availability of technical support through universities and research centers.

- It is necessary to strenghten the institutional framework for the development of this subsector through: the establishment of a new consultative organization at high

level; additional support from the armed forces to develop the scientific research and technical development infrastructure; strenghtening of research infrastructure for microelectronics and informatics; the establishment of specialized information and technical services; strenghtening and coordination of the installed capacity for research.

- It is also recommended to establish a series of actions and mechanisms to improve the communication within the subsector, such as :

  . To produce, through the professional electronic enterprises association, the catalog of products, services and technical capacities of the different companies
  . To give continuity to the Electronic Symposium and to edit an annual publication about it.
  . To improve the communication with the armed forces.

The fact that the I Electronic Symposium was organized with the participation of the Ministries of Defense, Industrial Promotion, Education and Science and Technology, and also with that of the Central University, the Engineering Foundation and the Professional Electronics Association, shows the great interest that exists in Venezuela, in all these sectors, to establish the appropriate framework to favor the development of electronics and in particular of microelectronics. Venezuela has a clear understanding of the potential that the country has in this field and the benefits that could be obtained from it.

Through the National Council of Scientific and Technological Research (CONICIT) it has been proposed to create the Commission

for the Development of the Research and its Applications in Microelectronics. This Commission should study the state of microelectronics in Venezuela and the feasibility to establish industrial plants for integrated circuits, components and electronic parts. Among the areas of possible studies of the Commission, the following have been indicated :

a. Integrated circuits
b. Integrated devices
c. Hybrid circuits
d. Optic fiber systems and devices
e. Active and passive microwave devices
f. Automated systems
g. Microprocessors applications

It is also recommended that the Commission "provides guidelines to establish appropriate quality control and standardization systems that are needed for the sector and also indications about the mechanisms to favor better ties between research and industry."

The R&D activities in microelectronics in Venezuela are concentrated mainly in the "Fundación Instituto de Ingeniería", in the Venezuelan electronic industries and in the institutes associated to specific sectors like the Venezuelan Petroleum Institute, the research groups of the Venezuelan Telephone Company (CANTV) and in the institutions like the Venezuelan Institute of Scientific Research (IVIC), the Central University and the Simón Bolívar University; these universities and the IVIC also play a very important role in training specialized personnel for this area.

The "Fundación Instituto de Ingeniería" is the most active organization in this field with high technology projects of industrial relevance, in fields like hybrid circuits, solar cells and power diodes. The "Fundación" has the objective to maintain

a high level of scientific and technological quality in its work and is therefore making big efforts to train their personnel in the best universities. At this moment they have 5 PhD students in foreign universities in different areas of microelectronics. For the near future "Fundación" has specific goals related to the computational systems to support the design of electronics circuits and in different technological aspects related to the manufacturing of circuits. Taking advantage of the silicon foundries available in other countries, they have considered the fabrication of custom and semi-custom circuits for telephone system applications, as a first step in this direction. In the area of telecomunications, the "Fundación" is also looking to improve its capacity in fiber optics and digital linkages through microwaves; it is also trying to widen its line of microprocessor applications extending its present developments in local area networks to microprocessors networks for the control of industrial plants and also networks for office automation.

Venezuelan industries are very active in technological development, most of the companies created in the last 10 years have their own technical capacity and they have also been able to commercialize efficiently their own products. They have used this technical capacity to improve their negotiation capabilities when they acquire complementary technology from other companies. Some of the examples of products developed by these companies are the following :

AETI. Supervisory control and data acquisition systems.
AVTEK. Voltage regulators. Insulator transformers. Line conditioners. Uninterruptable power supplies.
DISTELCA. Office automation software. Telex computer interphases.

EYT. Supervisory system for lifts. Street light control systems. Telemetry and control system. Telephone equipment.

FABELCA. Control microcomputers. Software systems. Programmable controlers. Maintenance services for microcomputerized equipments.

FONOLAB. Telephone devices. Operations tables. Communication display systems. Telephone exchanges interphases and adapters. Rural public telephone exchanges. Telephone exchanges. Combined telephoning systems.

INTERBA . Taxi-meter. Speed register.

MICROTEL. Systems to identify telephone suscriptors. Telephone exchanges. Control systems for lifts. Rural telephone exchanges.

VOLTEK. Autonomous clocks. Centralized clocks. Information displays.

XYNERTEC. IBM-PC compatible microcomputers based on foreign technology with a local technology integration program that will allow it to dominate all the electronic circuit plus the frame and power sources.

Most of these companies have been organized after 1975 and have been growing at an annual average rate of the order of 45% . All of them are based on their own technology and have given a great emphasis to commercialization, user's services and to adaptation of their programs to specific requirements of the user and to insure competitiveness in quality and price. A difference with companies of other sectors is that in these companies there is a permanent dedication to the R&D activities ant that is why they have about 40% of their engineers and

technicians devoted to this type of activities.

It is interesting to observe that many of these professional electronic companies have been initiated with managerial efforts of highly qualified engineers that have developed their own products, with their own design and engineering, as a starting point of their companies. In general, their initial rate of return has been low; as the companies have been learning to develop their own products, improving their own design and engineering, the rate of return has improved and at the same time they have been able to take a larger share of the market. A report produced by Mr. Carlos Chacón L. in August 1984 points out: "The fact that this small number of enterprises have developed and commercialized more than 30 products, many of them incorporating advanced technology, give us a good measure of their technological capacity in the application of electronic technologies and it also suggest their high potential for the development of systems and equipments much more complex than those that have been designed and adapted for the specific needs of the market so far". Mr. Chacón reports also the fact that, during the last three years, these companies have initiated on the average about seven new R&D projects each year, with significant investments in each of them.

Successful research projects include the development of commercial products, both in hardware and software. They have been achieved because of the high qualifications of their engineering personnel, many of them with postgraduate degrees and with previous experience in research institutions.

It is important to underline, from the same report of Mr. Chacón, the strategy elements that these industries have been

using to define their products:

a. To take advantage of the market "niches" generated by local conditions that demand equipment with different specifications than those used standardly elsewhere.

	IMPORTED	NATIONAL
* Voltage regulators with wider operational range. Voltage variation range	15%	25%

b. Universal designs that allows the compatibility among equipments of different origin and the modernization of obsolete equipment.
   * Digital interphases to identify telephone subscribers and to allow direct international dialing in electromechanical telephone exchanges.
   * Multi-frequential signaling for decadic telephone exchanges.
   * Detailed billing system (DDN)
   * Telex-computer interphase.

c. Designs incorporating recent components, achieving the fabrication of more advanced equipment than those that are available at the moment in the international market.
   * Telephonic exchanges PABX, incorporating a series of special characteristics to improve those existing in the market.
   * Modular street light system with distributed control
   * Design of systems and equipment with appropriate specifications for the particular needs of the user.
   * Lift control system

The young Venezuelan electronic industry is giving signs of dynamism, strength and competitiveness that indicates the great potential it has for future development, if there is a more ambitious governmental policy to support electronics. It

is very likely that a governmental policy will be designed with some of the following objectives : To make a better use of the national market, and specifically of the public sector market, to favor preferential financing for R&D activities, to devote more resources for the research and development groups in the universities and institutes. With these kind of policies it is foreseeable that the process of establishment and development of electronic companies will be accelerated with an important multiplying effect in the Venezuelan economy.

REGIONAL COOPERATION IN RESEARCH AND DEVELOPMENT IN MICRO-ELECTRONICS.

There is no doubt that in the long range the only way for the Latin American Countries to achieve a significant role in microelectronics at the world level is on the bases of a regional cooperation. In this way it could be possible to take advantage of the market, the industrial capacity and the scientific and technological potential of the region as a whole.

This cooperation would benefit countries least advanced in this field through the training of human resources, the support to start application programs, and the understanding of tools and processes that are in use or in development in other countries of the region, and in general, to facilitate them the access to information and experiences of great value to define opportunities, plans and specific programs.

All countries in the region, and specially those that are more advanced, could benefit from the access to markets, innovations and human resources of the whole region. At the same time it is possible to think in terms of more ambitious regional programs and projects, that could not be feasible with the resources of one country alone.

Regional cooperation in human resources could take advantage of the very costly infrastructure of laboratories, computers and specialized installations of the microelectronic groups in the different higher learning institutions, favoring complementation and better use of the resources. The advantages in language, culture and geographic vecinity, could mean an acceleration in the training of specialists. This cooperation

could mean also the use of the region's resources in the region itself, minimizing external flows of foreign exchange because of this concept.

The realization of cooperation projects like the "multi-project chip" that is suggested in the report of the mission to Venezuela, Brazil and Argentina,* will allow not only to share experiences and to accelerate the development of associated technologies in each country, but also to facilitate the communication among research groups and industries in the whole region, ensuring future benefits coming from a greater collaboration.

The dynamic performance of industries in informatics, telecommunications, professional electronics and electronics in general, within the region, opens very big opportunities for industrial and technological complementation. This complementation could be achieved as far as there are better basis in each country to identify opportunities to understand and evaluate what is being done in other countries in the region and to assimilate and apply electronic technologies.

There is a difference between what has been observed before in fields like consumer electronics, in which each country was pretending to have everything necessary to produce locally a whole range of products with little margin for regional complementation, and what happens now in the fields of informatics, telecommunications, professional electronics and microelectronics as such, that are so wide, complex and dynamic that open real and big possibilities for complementation; it becomes not only pretentious, but practically impossible for one country alone to cover the full spectrum of possibilities.

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* See document ID/WG.440/5.

The suggestions made in the mission's report that was mentioned before, to promote meetings, publications and broader regional communication among researchers, industrialists and authorities, could facilitate the definition of more specific opportunities for scientific and technical cooperation and also opportunities to improve the existing mechanisms to finance, promote and coordinate this cooperation. Acoording to the observations of the same mission and considering what has been said in this report about research and development in microelectronics in Latin-America, it can be assured that the establishment of the "Red Microelectrónica Latinoamericana" (REMLAC) will favor cooperation not only in research and development, but also in different industrial an commercial aspects in this field.

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in the ECLAC Region (REMLAC)*

Caracas, Venezuela, 3-7 June 1985

REPORT ON THE UNIDO MISSION PREPARATORY TO THE ESTABLISHMENT OF A REGIONAL SYSTEM FOR MICROELECTRONICS IN LATIN AMERICA (REMLAC)**

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* Co-sponsored by SELA/ECLAC.

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CONTENTS

	Page
Introduction	1 - 2
Research and development	2 - 4
Training	4 - 5
The Latin American electronics industry	5 - 6
Governmental organizations	6 - 7
Structure of the REMLAC System	7 - 8
Recommendation of specific REMLAC actions	8 - 9
Annex on Mexico	10 - 11
Abbreviations	12

Introduction

A number of regional meetings have revealed the importance of microelectronics in Latin America. It has become clear that this technology can provide an impetus to the industrial development of the region, on the one hand, by creating opportunities for the establishment of new rapid-growth enterprises and, on the other, by providing equipment and services that will have the effect of improving the efficiency and competitiveness of many other economic sectors.

Within this framework, the importance has been recognized of establishing mechanisms to encourage and support regional co-operation in the field of microelectronics, with specific reference to research and development, training, and industrial and commercial complementarity.

In the light of these facts, the United Nations Industrial Development Organization (UNIDO) is sponsoring a meeting to be held during the month of June 1985 for the purpose of defining the scope of the "Regional System for Microelectronics in Latin America" (REMLAC) and of identifying the machinery required to initiate its activities.

The purpose of this mission was to review the activities being conducted in this field in Argentina, Brazil, Venezuela and Mexico and to suggest specific areas of interest to serve as a basis of discussion with a view to achieving concrete results at the June meeting.

The mission found that the policies pursued in all the countries visited accorded priority to the development of microelectronics, not only in terms of applications, but also with respect to the promotion of the design and local production of hybrid and special circuits. The most important areas of application are telecommunications and data-processing, which share a number of common components, so that as a matter of policy these two fields and microelectronics as such are coming to be increasingly regarded as an integrated whole.

Attention should also be called to the relationship that exists, from the technological standpoint, between microelectronics per se and such applications as photovoltaic cells, lasers, power transistors and solid-state devices in general. There is no question that a microelectronics development strategy will spark off advances in other areas as well.

There already exists in Latin America an installed microelectronics capacity both at the governmental level and in the industrial sector as such. This potential varies from country to country, but all the countries visited possess the necessary assets for rapid expansion in the microelectronics area, viz:

(1) All the countries visited have strong university programmes in microelectronics coupled with extensive experience in the training of the necessary human resources.

(2) Similarly, there are government research and development institutions that maintain close ties with the universities and are actively working on the application of microelectronics to the various problems of

national industry. As a result, each country has developed a specific capacity which, although occasionally overlapping that of the other countries, also represents a useful element of complementarity in regional co-operation.

(3) In each of the countries visited there is an expanding national industry which operates with original designs and which is generating an ever-increasing demand for the domestic development and manufacture of electronic circuits and components.

(4) Each of the Governments has formulated or is in the process of formulating a comprehensive programme which, albeit at different stages of maturity, covers the full range of activities in the areas of microelectronics, electronics and data-processing.

The visits carried out revealed that microelectronics has advanced very rapidly in the Latin American region in recent years to the accompaniment of dramatic growth in the existing infrastructure. In the case of Brazil this infrastructure is already supplying the national and international market, and is beginning to supply the national market in Venezuela, Mexico and Argentina, although the principal trend in these latter countries has been towards the manufacture of electronic equipment for a variety of applications.

This entire picture points to the need to develop a production capacity for electronic components at the regional level not only because of the strategic importance of this capacity, but also because of the economic benefits to be gained from the supply of the domestic market and from the existing export potential.

Within the region there is great interest in the establishment of the REMLAC System, as indeed in all forms of co-operation in the microelectronics area. In every case the persons interviewed (see annex II) showed keen interest in the REMLAC concept, since it is quite clear that heavy pressure is being brought to bear both by the developed countries and the transnational industrial groups and that no country can aspire to cover all the areas simultaneously and competitively.

Similarly, the existence of this marked regional interest is reflected in Decision No. 221 of the Tenth Council of the Latin American Economic System (SELA), inspired by the Quito Declaration and Plan of Action and the informal meeting on data-processing and microelectronics held in Caracas in 1985.

Research and development

Since microelectronics is an eminently high-technology field, it is essential that its growth should be based on research groups backed by an adequate infrastructure. It is worth while noting that the four countries visited have for more than ten years been conducting programmes both in the field of microelectronics *per se* and in such related areas as solid-state physics, chemical processes, etc., with the result that they now have trained specialists currently engaged in research, teaching and industrial activities. These groups represent a valuable asset for the promotion of progress in this area.

In Venezuela, the Engineering Institute Foundation (FII) has succeeded in establishing an infrastructure associated primarily with hybrid circuits, fibre optics, power transistors and microprocessors. The Foundation has a staff of 23 research specialists and adequate pilot-scale industrial facilities, at which new technologies can be brought to full maturity before they are put to industrial use. The Venezuelan Institute of Scientific Research (IVIC), which employs two research specialists, also has experience in the design and manufacture of integrated circuit devices and has begun work on computer-assisted circuitry design. IVIC has trained the personnel who now form the greater part of the technical staff of the Engineering Institute Foundation and has supplied most of

the current directors of the country's professional design enterprises. At Simón Bolívar University there are also two groups totalling four researchers involved in the study of photovoltaic cells.

In Brazil there are many research groups working in the microelectronics field. The most important are to be found at the University of São Paulo, Campinas University, the Data-Processing Technology Centre and the Telebras Research and Development Centre. The result has been the gaining of experience, already transferred to the industrial sector, in the manufacture of semiconductors, the design of integrated circuits, the production of hybrid circuits and in technologies relating to power transistors, solar cells and fibre optics.

The Brazilian research infrastructure in this area has substantial growth potential and constitutes a Latin American asset that can be used to support the efforts being undertaken in other countries.

Microelectronics research in Argentina is concentrated primarily at the National Centre for Electronic Component Research (CENICE), which is a part of the Armed Forces Technology Centre (CITEFA). The technology developed by CENICE in hybrid circuits is being passed on to industry. The major printed circuit companies were formed from CENICE personnel and are currently working on the design of integrated circuits and on the manufacturing processes for these circuits, with particular emphasis on CMOS technology.

Also within CITEFA, the PRINSO (Solid-State Research Programme) group has extensive experience in infrared detectors and solid-state batteries using original technologies, some of which have already been transferred to industry. There is also a group at La Plata University working on the computer-assisted design of circuits and digital data networks.

In Mexico research has focused on integrated circuits and solar cells, primarily at the Centre for Research and Advanced Studies of the National Polytechnical Institute, the National Institute of Astrophysics, Optics and Electronics, Puebla University, and within a number of groups at the National Autonomous University of Mexico.

Co-operation in research and development may be very fruitful in view of the common interest in such subjects as: computer-assisted design, design and manufacture of special integrated circuits, the supply of electronic-grade materials and inputs, the design and production of power devices, fibre optics, and test and measurement technologies for quality control and as certification aids in microelectronics and other fields.

Extensive contacts already exist between the research and development groups working in the microelectronics area in Latin America. For example, Argentine, Venezuelan and Mexican specialists can frequently be found attending seminars and meetings on microelectronics organized in Brazil. It would be useful if at these conferences and at those of other related professional groups (e.g., groups working in solid-state physics and computer sciences, among others) round-table discussions and special meetings could be organized for the purpose of analysing Latin American co-operation in microelectronics research and development. This would provide a means of identifying subjects of common interest for information exchanges and the formulation of co-operative projects. It is interesting to note the similarity between the work carried out by the International Electrical Research Exchange (IERE) and the REMLAC concept, since IERE has no permanent secretariat, this body relocating every 18 months to the venue of the next meeting, from where the activities for that period are co-ordinated. On the other hand, the existence of national plans in the field of microelectronics, together with the setting of the associated priorities and the assignment of specific tasks, also represents a significant supporting factor in promoting research and development co-operation.

It might be suggested, in this respect, that the focal points of the System should undertake to provide the national agencies involved in promoting, co-ordinating and/or conducting research with information on the plans and achievements of the other countries of the region. It would also be useful if periodic, perhaps biannual, meetings could be arranged to analyse co-operation between various countries in research and development, similar to the meetings organized by the International Electrical Research Exchange, in which every 18 months research groups from many countries come together to discuss and describe their research programme and the principal results achieved. It is important to note that for Latin America there already exists the Hispanic-American Association of Telecommunications Research and Studies Centres (AHCIET), which has maintained a busy schedule of meetings for exchanges of information and the encouragement of collaboration between the Latin American countries.

Meetings of the kind proposed would be sponsored by the System and would provide a forum for general reviews of the state of the art in research and development in each of the countries, as well as for discussions of priority areas of interest selected by common agreement at the previous meeting. Exchanges of this type would supplement the expert group meetings convened to analyse specific details not only in the form of seminars and workshops, but also through discussions, training and the implementation of the joint projects formulated under the System.

As a supporting activity in furtherance of research and development co-operation, it would be useful if every country were to publish and disseminate bibliographical information on studies completed along with lists of projects in the process of implementation in this field. To this end, it should be possible to use the experience gained by such institutions as the Centre for Scientific and Humanist Information of the National Autonomous University of Mexico in the preparation of Latin American bibliographies and indices. Similarly, these activities could be pursued through the journals that already exist in several countries, such as TEC in Venezuela and the Revista Telegráfica Electrónica in Argentina.

Training

More than 20 Latin American universities (see annex I) offer programmes in microelectronics ranging from the design and production of printed, hybrid and integrated circuits to the fundamental concepts required for the manufacture of new materials and devices for use in electronics.

Universities such as those at São Paulo and Campinas offer programmes covering a wide range of the activities mentioned, whereas others (e.g., the National University of the Coast in Argentina) deal with very specific problems, such as the production of electronic-grade materials.

It would be useful if there were greater co-operation between all these institutions for the purpose of more effectively using the experience available in the region with respect to:

- Educational objectives;
- Study programmes;
- University-industry relations;
- Manager training;
- Infrastructure development;
- Co-operation among the universities and institutes of the region.

There might also be planning of post-graduate programmes of a complementary nature, covering in greater scope and depth a range of topics relating to various scientific and technological aspects of microelectronics. As a short-term measure, teacher exchanges and fellowship financing could be encouraged, both for the organization of post-graduate courses as well as for on-the-job training.

It would seem useful for the post-graduate programmes to address the great demand for specialists in microprocessor and electronic engineering applications which are of fundamental importance in enabling each country to develop the kind of electronic design capacity required for the generation of microelectronics demand. This design capacity must reflect the specific needs of each country, with particular reference to the logical and electrical aspects of circuit design. It would also seem advisable to cover the areas of telecommunications and data-processing, along with the circuitry required for the monitoring and control of equipment and processes.

It is likewise important that post-graduate programmes be introduced in the area of computer-assisted design, including the development and use of simulators, and on the processes employed in the production of integrated circuits, such as metal deposition, mask production, diffusion, etc.

In general, there is evidence of great interest in ensuring good basic training through the post-graduate programmes, with this approach supplemented by the kind of research and development activities that will slant the training towards the specialized areas of the research groups.

Considering the heavy investments required for these research groups, it has been deemed advisable that the post-graduate programmes should be planned in accordance with complementarity criteria permitting more effective use of resources.

The information gathered does not permit a more detailed analysis of the modalities and objectives of a Latin American co-operation plan for human resource training in microelectronics; however, it is worth while noting the importance ascribed to this subject in all the countries and the interest expressed by the institutions of higher learning in improving their co-operative ties with other institutions of the region. Accordingly, it is strongly recommended that, as part of the System's activities, consideration should be given to the organization of periodic, possibly biannual, meetings during those years when the research and development meetings previously suggested are not held, for the purpose of improving inter-institutional communications, discussing collaborative regional measures and strengthening bilateral co-operation.

Considering the rapid pace of change in the field of microelectronics and the intensive programmes in advanced areas conducted by many universities outside the region, it is essential that efforts be continued to train specialists, primarily at the doctorate level in other countries, by taking full advantage of the contacts that already exist and by capitalizing on the region's negotiating strengths. It should be stressed that excellent relationships already exist between Latin American institutions and universities and universities in various other countries of the world, such as Stanford, Berkeley, M.I.T., Rochester, North Carolina, Waterloo, Edinburgh, Toulouse, Aachen, Nagoya, etc.

Contacts have also been established with universities in Korea, Taiwan and India, and it would seem advisable to make maximum use of the potential opportunities for co-operation with these institutions.

The Latin American electronics industry

The Latin American electronics industry has made a major effort to develop machinery in support of regional co-operation. One result has been the

establishment of the Latin American Association of the Electronic Industry (ALAINEE) and of the equivalent association for the Andean Pact countries (ANDINEE). Unfortunately, there has been a substantial reduction in the activities of these associations, in part because of the general recession that has struck the countries of the region, but also for the reason that these activities were focused primarily on industries producing electronic products for mass consumption - an area in which all the countries have developed their own capacity and in which there were few opportunities for co-operation. The measures now being taken in a number of countries of the region with a view towards developing the electronics industry through growth in telecommunications, data processing and microelectronics are leading to new possibilities for co-operation. What are involved are more sophisticated products and technologies that have a more extensive range of applications which cannot all easily be mastered by any single country. New problems are also emerging in connection with the supply of components, materials, precision parts and services, which are of interest to all manufacturers. The same is true of the computational tools required for design and for the technological support of production processes, quality control and certification.

These fresh opportunities for co-operation are opening up rapidly as the industries in question experience dramatic growth. It may be said that it was in 1983 that these related problems began to become more clearly delineated - problems that are acquiring ever greater importance as new industrial enterprises come into being and their volume of production increases. Consequently, it would be extremely useful if the REMLAC System were to promote communications and exchanges and, at a later date, co-operation between the industries of the different countries of the region.

Considering that nearly all the fast-growing enterprises in this field operate their own research and development programmes, industrial co-operation may lead to joint developments and, in all likelihood, to new financing arrangements, such as the bilateral risk-sharing schemes that have been promoted by the National Council for Science and Technology of Mexico, or to regional machinery for the financing of research and development projects conducted by industrial enterprises in collaboration with research institutions.

More broad-based co-operation activities, backed by governmental support, might serve as the basis for a Latin American microelectronics development programme, similar - although surely far smaller in scope - to the European SPRIT programme.

On the basis of the preceding considerations, it is recommended that the System should promote communications between the industries of the region through publications, meetings and, possibly, the creation of a regional data network. It is suggested that this information should be as accurate as possible and relevant to the problems of industry, following such models as the UNIDO microelectronics newsletters. Along these same lines, it is likely that the regional institutions themselves will find it useful to establish mechanisms, such as a Latin American Microelectronics Industry Association, as a means of providing a solid basis for future co-operation in this field.

Governmental organizations

Considering the technological complexity of microelectronics and the associated investment burden, it is imperative that the Governments of the individual countries should establish priorities and the appropriate machinery to promote the development of this industry. The national policies of Brazil and Argentina, two countries that accord high priority to microelectronics and have laid the basis for its growth in integration with the expansion of the data-processing and telecommunications sectors, represent a regional advance that

should make it possible for the other countries to fine-tune their own policies in this field. The regional meetings on microelectronics sponsored by the Economic Commission for Latin America and the Caribbean (ECLAC), the Latin American Economic System (SELA) and UNIDO have provided excellent forums at which Latin American officials have had an opportunity to familiarize themselves with the experience, plans and programmes of the area countries, in addition to generating great interest in regional co-operation. The problems involved are too complex to have been exhaustively dealt with in the few meetings that have so far been held, and it might be suggested that, with the support of the regional agencies and of the System itself, a series of meetings having more specific agendas should be organized to permit more extensive coverage of governmental measures in respect of microelectronics. The subjects for discussion might be drawn from the reports of the previous meetings, with an effort made to focus the attention of the new meetings on specific items so as to permit the participation of officials in charge of general policy for the promotion of microelectronics together with representatives from other sectors of government involvement. These might be, depending on the circumstances, officials in charge of human resource training, scientific and technological research, telecommunications, data processing, financing, technology development projects for industry, governmental procurement policy, standardization, etc.

In this connection, the System should encourage each country to compile bibliographies on the reports, official documents, regulations and various sources of governmental information on microelectronics for the purpose of circulating these materials in the other countries of the region. Similarly, at the regional level, organizations such as SELA should be encouraged to perform a similar documentation function with respect to the information generated at events or in regional studies.

Structure of the REMLAC System

The essential idea of the System is to establish effective mechanisms to permit the flow of information and the organization of events so that projects may be implemented and the various countries kept informed not only of activities in the participating countries of the System itself, but also of international trends. The System will not have a structure of its own, but will rely on the structure that already exists; neither will it create any special Secretariat or additional machinery for its operation. The System's principle elements will be:

(1) The nodal points, i.e., the national centres or groups comprising the System. These may have different characteristics, but in general they will be institutions with a microelectronics research and development capacity. There will be only one nodal point per country, whereby the other national centres and institutions will make use of the country's nodal point for participation in the System. Each of the countries comprising the System must have a nodal point over the medium term. The System may assist those countries lacking sufficiently developed centres in establishing them and in training their personnel.

(2) Interaction within the System. The basis for the interaction of the nodal points will be provided through the meetings held by the System. These meetings will be organized on a rotating basis among the members and will lay down the System's areas and programmes of co-operation for the ensuing period. These programmes will be implemented by the participating countries.

(3) Internodal ties. It is necessary that stable channels should be established to permit the various nodal points of the System to interact among themselves. Consultation machinery, meetings and newsletters are

among the typical devices used for this purpose, in addition to personal contacts. Over the medium term consideration should be given to the possibility of establishing a data link between the System's various members to facilitate interaction and a rapid exchange of information.

(4) Regional nodal points. The System's regional nodal points, defined as "centres of excellence", would form the possible nodal points of the System. Considering the broad range of activities within the microelectronics field, the establishment of more than one regional nodal point might be necessary. From this perspective, and following an offer by the Government of Venezuela, a group of experts evaluated the facilities of the Engineering Institute Foundation (FII). This evaluation established the feasibility of FII's functioning as a regional nodal point, and proposals for its improvement will be submitted. It is anticipated that it will be necessary to identify specific regional nodal points in various areas.

(5) Financing. The System's activities will be financed by the countries themselves, UNDP and other international organizations. The budgets, extending over several years, are to be prepared at the meetings, and no project is to be begun if adequate financing has not been provided.

Recommendation of specific REMLAC actions

1. Multiproject chip

It is considered of great interest and importance that a joint and specific project be formulated as part of the activities of the System. It was generally agreed in the countries visited that the System's participating countries should formulate a project for the manufacture, at a silicon foundry to be selected, of a multiproject chip. Such a chip would consist of a series of circuits of commercial interest to each country, designed by each of them. This implies that each of the participating countries would, in co-operation with the others, develop a capacity for the design of highly complex integrated circuits. Each of the countries would finance its own infrastructure, and a project would be formulated for UNDP or some other international agency for the training and meetings necessary for carrying out the design and for covering the costs involved in disseminating the chip. From the point of view of the System, such a project would be of value, both in strategic and commercial terms, to the countries involved and would result in an installed infrastructure for the production of custom-designed circuits within the region.

2. Quality and production engineering for components and equipment

With the possible exception of Brazil, the region lacks extensive experience in quality control techniques and in electronic component and equipment production methodology. There is an evident need to implement a joint project to make it possible, specifically, to draw on the existing experience as a means of learning the various techniques of equipment evaluation and control. The basic idea would be to develop the necessary technology so as to achieve regionally the kind of procedures for test evaluation and standardization that will also satisfy international requirements. In addition, this activity would make it possible to increase the volume of exports. Dr. Dmitruk of Argentina's National Institute of Industrial Technology (INTI) will shortly be submitting a specific proposal for a joint project of this kind.

3. Standardization and certification of equipment

It would be desirable if within the region a number of generally accepted standards could be established for both components and equipment. This would lead to greater compatibility of products manufactured by the various sectors of the

industry, which in turn would permit the more extensive integration of equipment at the regional level. Moreover, the adoption of common standards would introduce a high level of compatibility for equipment manufactured within the region and greater independence on other, extra-regional, countries.

4. Communication and publicity

There must be greater communication between the countries comprising the System and greater publicity of all their activities, both of a commercial nature and in the area of research and development. This will be a very important task for the nodal points of the System. Consideration should also be given to the possibility of creating a System newsletter, of using already existing machinery and of establishing permanent sections on Latin American activities in already existing journals, such as the Journal de Microelectrónica (Brazil), the Revista Telegráfica Electrónica (Argentina) and TEC (Venezuela).

The System might also encourage the writing of articles on programmes, actions and achievements in regional microelectronics and promote their distribution to the principal newspapers as a means of generating a greater awareness of this subject.

There is likewise a need to publicize the work being performed by the research and development institutions of the region in order that machinery may be devised to provide assistance for specific tasks. Information should also be developed on the availability of microelectronics experts and consultants, both in the region's research and development institutions and its industry, whose services might be of value to other countries.

5. Notes on application

It would be desirable to formulate a Code containing notes on the application of devices, equipment, computation tools, specific standards, services and suppliers of microelectronics in order to save time and avoid a duplication of effort in the evaluation of already existing products in the Latin American countries. This Code might be centralized in one of the countries and could be fed through the evaluations conducted by the System's various institutions.

6. Purchase and acquisition of materials

Measures should be taken within the System to secure the supply of inputs and materials from other countries, as well as to improve the negotiating position of the countries by presenting a common front. Similarly, machinery should be set up to provide greater publicity and information on the suppliers of components and materials already operating in the region both within the existing electronics industry and at the research and development institutions.

7. Post-graduate support programmes

Support should be given to Latin American post-graduate training programmes in microelectronics. Specifically, the necessary machinery should be created for the exchange of teachers, the awarding of fellowships and the development of curricula, as well as for regional complementarity in various areas of microelectronics. In particular, it would be useful to design courses for the purpose of creating new groups in those areas of microelectronics not yet represented in every country.

ANNEX ON MEXICO FOR THE REPORT ON THE UNIDO MISSION PREPARATORY TO THE ESTABLISHMENT OF A REGIONAL SYSTEM FOR MICROELECTRONICS IN LATIN AMERICA (REMLAC)

Mexico is keenly interested in participating in REMLAC. This was made clear by Dr. José Warman, Director for the Electronics Industry and Industrial Co-ordination of the Ministry of Commerce and Industrial Promotion, who stressed the fact that for more than three years the Mexican Government had been lending its support to the organization of a regional meeting on microelectronics, noting that there was currently even greater interest in view of the advances that had been achieved in this field.

The attitude of industrialists, such as the President of the National Chamber of the Electronics Industry and Electrical Communications (CANIECE), and of the research community is also positive, there being an awareness of the advantages to be gained through the establishment of better communications with other regional countries and the undertaking of joint projects.

There has been a considerable acceleration in recent years in Mexican work in electronics. The industry, particularly in the telecommunications, data-processing, professional electronics and consumer-products branches, has grown rapidly to the accompaniment of increased integration with respect both to production and to engineering and technological advances.

In the telecommunications area, ambitious programmes have been launched to digitalize the country's telephone exchanges and expand the microwave and satellite communication systems. With respect to data-processing, more than 80 national manufacturers of microcomputers, peripheral apparatus and components have been successfully established, in addition to the manufacturers operating on the contractual buy-back principle ("maquiladores") and producing for the export market. In the field of professional electronics, using national technology several score products have been developed that are advantageously competing with similar foreign items. As far as consumer products are concerned, Mexico has begun the domestic production of television sets and radio receivers as a means of effectively competing with contraband imports. Domestic production has also been achieved in such areas as printed circuits and components, including transistors and resistors, under internationally competitive quality and price conditions.

Furthermore, in the research and development area, there are already important telecommunications groups, both in industry (the Telecommunications Development Institute (INDETELEC), Teléfonos de México, etc.) and at governmental institutes and centres of higher learning (the Telecommunications Research and Development Centre (CIDET), the Centre for Research and Advanced Studies of the National Polytechnical Institute (CINVESTAV), the Engineering Faculty of the National Autonomous University of Mexico (UNAM) and the new Telecommunications Institute, among others). In the field of data-processing as well, groups have been formed in industry (MEXEL, IBM, NCR, etc.) and at institutes, such as CINVESTAV, the Institute for Research in Applied Mathematics, Systems and Services (IMASS), the Instrument Centre, the University Computation Programme (these last three at UNAM), the Institute of Electrical Research (IIE), the Mexican Petroleum Institute (IMP), etc. In professional electronics there have been developments in many industries, the majority in collaboration with such institutes as IIE, IMP, the regional technological institutes, the Autonomous Metropolitan University (UAM), the Institute of Engineering at UNAM, and others. Work is also going forward with computer-assisted design and computer-assisted manufacturing at many of these

institutes. Component-associated research and development is concentrated at the institutions of higher learning, among which particular mention should be made of the University of Puebla, CINVESTAV, the Institute of Physics and the Institute of Materials of UNAM, as well as the National Institute of Astrophysics, Optics and Electronics (INAOE). This work is primarily concerned with silicon (polycrystal, monocrystal and amorphous) and with the design and production of integrated circuits.

At practically all the groups mentioned there is a previous history of interaction with other Latin American countries, particularly through visits, information exchanges and participation in regional technical meetings.

There is an awareness of the inadequacy of co-operation in the microelectronics area among the research groups and industry. This is due primarily to the fact that industrial development in this field is still in its infancy and the groups engaged in the design and development of equipment and devices have not displayed an interest in the more extensive use of customized and semicustomized integrated circuits. But this trend, which is becoming daily more evident in countries like the United States of America, is beginning to make itself felt, and there is already keen interest in the establishment of an electronics industry support centre to facilitate the work of design, co-operation with silicon foundries and, in general, prototype development and evaluation.

The Mexican Government is directing particular attention to the development of the electronics industry and, to this end, is preparing a "comprehensive programme for the development of the electronics industry" (PIDIE), which will supplement the growth that has already been achieved in recent years by promoting industries, mainly in the computer area, and by extending coverage at this time to professional electronics, consumer electronics, biomedical electronics, microelectronics and software.

This programme includes the encouragement of electronics production through conventional measures of promotion in co-ordination with the development of applications of interest to the quasi-governmental sector, which is also expected to participate in and support the growth of new electronics industries. The strategy adopted envisages a series of measures of a scientific and technological nature that are to be carried out in concert with industry and the country's research and development community for the purpose of facilitating industry activities in this field. Among these measures there are plans to strengthen the research and development groups capable of generating electronic applications and to create technological support services to work together with industry in the design, development and production of prototypes and in technological support for the industrial-scale manufacturing of this equipment.

To this end, there is to be a restructuring of the service centre already mentioned, which will draw on the support of the quasi-governmental sector and private enterprise. This centre is being organized with the support of the Ministry of Commerce and Industrial Promotion, the Ministry of Energy, Mining and Quasi-Governmental Industry, the Institute of Electrical Research, and the National Chamber of the Electronics Industry and Electrical Communications. By virtue of its functions, this centre will represent an appropriate nodal point for the REMLAC System.

Abbreviations

CIDET	Telecommunications Research and Development Centre. It is part of the Ministry of Communications and Transport.
CINVESTAV	Centre for Research and Advanced Studies of the National Polytechnical Institute
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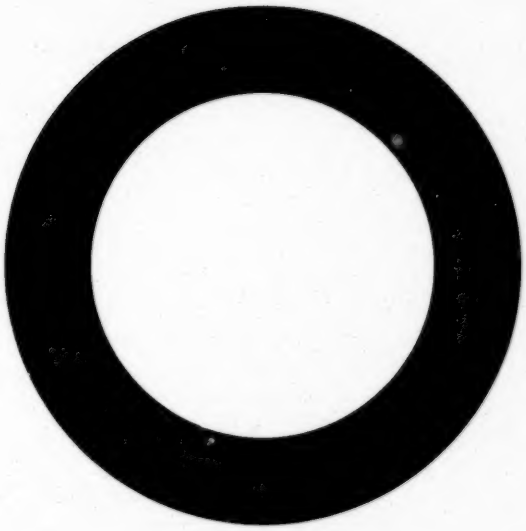
IIE	Institute of Electrical Research
IMP	Mexican Petroleum Institute
UAM	Autonomous Metropolitan University
INAOE	National Institute of Astrophysics, Optics and Electronics
SECOFI	Ministry of Commerce and Industrial Promotion
SEMIP	Ministry of Energy, Mining and Quasi-Governmental Industry
CANIECE	National Chamber of the Electronics Industry and Electrical Communications



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Regional Meeting for the Initiation of a
Regional Network for Microelectronics
in the ECLAC Region

Caracas, Venezuela, 3-7 June 1985

REPORT ON THE UNIDO MISSION PREPARATORY TO THE ESTABLISHMENT OF A REGIONAL SYSTEM FOR MICROELECTRONICS IN LATIN AMERICA *

Annexes

I. Programmes connected with microelectronics.

II. Places visited.

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ANNEX I

Programmes connected with microelectronics

VENEZUELA

The microelectronics industry in Venezuela arose from the activities of the Venezuelan Institute of Scientific Research (IVIC) which had, from its inception in the early 'sixties, an electronics group working on instrument design to back up the research done at the institute. This group was the origin of virtually all research and development groups working in Venezuela, as well as a fair number of the country's electronics companies.

If we define microelectronics as being concerned solely with electronic components, then work on microelectronics is conducted mainly in the research and development institutes, since the principal advances on an industrial scale have stemmed from the design of electronic equipment.

The activities and staff of the research and development institutes are as follows:

ENGINEERING INSTITUTE FOUNDATION (FII)

(26 research and development specialists)

(a) Hybrid circuits
(b) Components for integrated circuits and transistors
(c) Fibre optics communication systems
(d) Local micro-computer networks
(e) Micro-processor surveillance systems
(f) Manufacture of solar cells and panels
(g) Telemetry systems
(h) Computer-aided design.

VENEZUELAN INSTITUTE OF SCIENTIFIC RESEARCH (IVIC)

(3 research and development specialists and 1 electronic engineering post-graduate)

(a) Integrated circuits and components
(b) Ferroelectric materials
(c) Solar cells.

SIMON BOLIVAR UNIVERSITY

(6 research and development specialists)

(a) Solar cells
(b) Growth of mono-crystalline silicon
(c) Micro-processor applications.

LOS ANDES UNIVERSITY

(a) Materials for solar cells.

In addition to these activities, there are development laboratories attached to State undertakings such as the Venezuelan Telephone Company (CANTV) and the Venezuelan Petroleum Technology Institute (INTEVEP), which look into developments for their respective establishments.

Finally, there is a growing number of Venezuelan electronics companies which produce high added value equipment and/or components for this equipment. They currently manufacture the following products:

(a) Printed circuits
(b) Data capture systems
(c) Voltage regulators and line protectors
(d) Transformers
(e) Telex-computer interfaces
(f) Surveillance and monitoring systems
(g) Lift control systems
(h) Modems
(i) Telephone exchanges
(j) Telephone equipment including handsets
(k) Taximeters
(l) Electronic watches
(m) Data consoles
(n) Subscriber identification systems
(o) Personal computers.

These firms employ about 400 staff, more than half of whom are professional specialists and technicians.

BRAZIL

Of all the countries visited Brazil undoubtedly has the most extensive infrastructure, as regards both research and development activities and industrial capability. Owing to the shortness of the stay, it was only possible to visit some of the organizations actively working on microelectronics, mainly those in the region of São Paulo and Campinas.

Microelectronics in Brazil goes right back to 1965 at São Paulo University and the Physics Institute. The microelectronics laboratory was set up in 1970 and there was a lot of work done on microelectronics at Telebras and Campinas University in 1972. The Transit company was established in 1973 to manufacture diodes and transistors, but it was unsuccessful because its headquarters were far from the main industrial and academic centres.

In 1979 Brazil began to establish a general policy for the data processing sector through the Special Data Processing Department, which promoted the promulgation of the law on data processing. This law led to the establishment of the Data Processing Technology Centre (CTI) at Campinas.

It would be difficult to present a complete summary of microelectronics activity in Brazil and we shall therefore only mention a few areas of work at the organizations visited.

DATA PROCESSING TECHNOLOGY CENTRE (CTI)

(400 research and development specialists)

This recently-established Centre has four institutes, one of which deals with microelectronics. The Microelectronics Institute is involved in:

(a) Assembly of components and circuits
(b) Assembly testing
(c) Computer circuit design

(d) Mask design and manufacture
(e) Circuit metal deposition
(f) C-MOS n-well and integrated cell components
(g) Integrated circuit manufacturing processes.

The Centre also co-ordinates activities, promoting co-operation between universities, defining priorities and providing a technological base for industry. The main emphasis is placed on developing areas which are not covered by industry as support for the latter.

UNICAMP

Attention at UNICAMP is primarily focussed on aspects connected with the manufacture of fibre optics components and devices. The solid state laser and fibre optics developments made by this University have already found industrial application and further research is being conducted into solid state lasers.

SÃO PAULO UNIVERSITY

(34 research workers plus students and technicians)

(a) Growth of mono-crystalline silicon
(b) Computer-aided design
(c) Diffusion processes for integrated circuits
(d) Solar cells
(e) MOS integrated circuits
(f) Thin layer hybrid circuits.

TELEBRAS

(a) Computer-aided design for integrated circuits
(b) Thick layer hybrid circuits
(c) GaAs solid-state lasers.

Some outstanding examples of the work being done in Brazil are:

1. There are computer-aided design groups working on integrated circuits at CTI, USP, Telebras, Río Grande, Itaucom and SID.

2. There is an industrial plant for the production of mono-crystalline silicon (heliodynamic process).

3. There is a transistor production plant (AEGIS).

4. The SID company produces linear and digital integrated circuits at prices that are competitive on the international market and is beginning to work on gate arrays and standard cells.

5. There are about 180 Brazilian companies whose production ranges from the components described above to mini-computers and there are various plants manufacturing personal computers, telephone exchanges, etc.

ARGENTINA

BUENOS AIRES UNIVERSITY

(15 research and development specialists)

(a) Electrical properties of semi-conductors and piezo-electric devices.

ARMED FORCES TECHNOLOGY CENTRE (CITEFA)

1. National Centre for Electronic Component Research (CENICE)

(47 research and development specialists)

(a) Thick layer hybrid circuits
(b) Pilot plant for bipolar technology
(c) Computer-aided design of integrated circuits
(d) Quality control
(e) CMOS pilot plant.

2. Solid state research programme

(24 research and development specialists)

(a) Growth and assessment of infra-red detection compounds
(b) Solid state batteries.

3. CEILAP

(35 research and development specialists)

(a) Research into lasers and optics.

NATIONAL UNIVERSITY OF THE COAST (Universidad Nacional del Litoral)

(32 research and development specialists)

(a) Electrical and magnetic properties of non-ordered semi-conductors
(b) Silicon technology
(c) Solar cells
(d) Electronic grade chloroxylenes and ultra-pure gases.

NATIONAL UNIVERSITY OF THE SOUTH (Universidad Nacional del Sur)

(9 research and development specialists)

(a) Fibre optics
(b) Liquid crystals.

BARILOCHE ATOMIC CENTRE (CNEA)

(24 research and development specialists)

(a) Ion implants
(b) Growth of semi-conductor crystals
(c) Ferroelectric ceramic and piezo-electric transducers.

NATIONAL INSTITUTE OF INDUSTRIAL TECHNOLOGY (INTI)

(a) Metrology
(b) Micro-processors
(c) Development of telephone exchanges
(d) Quality engineering
(e) Numerical control
(f) Sensors and instrumentation.

MEXICO

Mexico is extremely interested in participating in REMLAC. This was made clear by Dr. José Warman, the Director for the Electronics Industry and Industrial Co-ordination at the Ministry of Commerce and Industrial Promotion, who stressed the fact that the Mexican Government had been supporting the idea of a regional microelectronics meeting for over three years and that there is even greater interest today because of the progress that has been made in this field.

Both the representatives of industry, such as the Chairman of the Mexican Chamber of the Electronics Industry and Electrical Communications (CANIECE), and research workers were also positive in their opinions since they appreciate the advantages of establishing better communications with other countries in the area and of developing joint projects.

Work on electronics in Mexico has speeded up considerably in recent years. Industry has expanded rapidly into manufacturing and technological development and engineering, principally in the fields of telecommunications, data processing, professional electronics and consumer goods.

In telecommunications there have been ambitious programmes to digitalize telephone exchanges and to extend the micro-wave and satellite communications networks. Progress in data processing is such that there are now over 80 Mexican producers of micro-computers, peripherals and components, as well as the manufacturers operating on the contractual buy-back principle ("maquiladores") and producing for the export market. In the field of professional electronics, using national technology, dozens of products have been developed that are advantageously competing with foreign items. As far as consumer goods are concerned, Mexico has begun the domestic production of television sets and radio receivers as a means of competing effectively with contraband imports. Domestic production has also been achieved in such areas as printed circuits and components, including transistors and resistors, under internationally competitive quality and price conditions.

Furthermore, in the research and development area, there are already important telecommunications groups, both in industry (the Telecommunications Development Institute (INDETELEC), Teléfonos de Mexico, etc.) and at governmental institutes and centres of higher education (the Telecommunications Research and Development Centre (CIDET), the Centre for Research and Advanced Studies of the National Polytechnical Institute (CINVESTAV), the Engineering Faculty of the National Autonomous University of Mexico (UNAM) and the new Telecommunications Institute, among others). In the field of data processing as well groups have been formed in industry (MEXEL, IBM, NCR, etc.) and at institutes, such as CINVESTAV, the Institute for Research in Applied Mathematics, Systems and Services (IMASS), the Instrument Centre, the University Computation Programme (these last three at UNAM), the Institute of Electrical Research (IIE), the Mexican Petroleum Institute (IMP), etc. In professional electronics there have been developments in many industries, the majority in collaboration with such institutes as IIE, IMP, the regional technological institutes, the Autonomous Metropolitan University (UAM), the Institute of Engineering at UNAM and others. Work is also going forward in computer-aided design and computer-aided manufacturing at many of these institutes. Component-associated research and development is concentrated at the institutions of higher education, among which particular mention should be made of the University of Puebla, CINVESTAV, the Institute of Physics and the Institute of Materials of UNAM, as well as the National Institute of Astrophysics, Optics and Electronics (INAOE). This work is primarily concerned with silicon (polycrystal, monocrystal and amorphous) and with the design and production of integrated circuits.

At practically all the groups mentioned there is a previous history of collaboration with other Latin American countries, particularly through visits, information exchanges and participation in regional technical meetings.

There is an awareness of the inadequacy of co-operation in the micro-electronics area between the research groups and industry. This is due primarily to the fact that industrial development in this field is still in its infancy and the groups engaged in the design and development of equipment and devices have not displayed an interest in the more extensive use of customized and semi-customized integrated circuits. But this trend, which is becoming daily more evident in countries like the United States of America, is beginning to make itself felt and there is already a keen interest in the establishment of an electronics industry support centre to facilitate the work of design, co-operation with silicon foundries and, in general, prototype development and evaluation.

The Mexican Government is directing particular attention to the development of the electronics industry and, to this end, is preparing a comprehensive programme for the development of the electronics industry (PIDIE), which will supplement the growth that has already been achieved in recent years by promoting industries, mainly in the computer area, and by extending coverage to professional electronics, consumer electronics, bio-medical electronics, micro-electronics and software.

This programme includes the encouragement of electronics production through conventional measures of promotion in co-ordination with the development of applications of interest to the quasi-governmental sector, which is also expected to participate in and support the growth of new electronics industries. The strategy adopted envisages a series of measures of a scientific and technological nature that are to be carried out in concert with industry and the country's research and development community for the purpose of facilitating industrial activities in this field. Among these measures there are plans to strengthen the research and development groups capable of generating electronic applications and to create technological support services to work together with industry in the design development and production of prototypes and in technological support for the industrial-scale manufacture of this equipment.

To this end, there is to be a restructuring of the service centre already mentioned, which will draw on the support of the quasi-governmental sector and private enterprise. This centre is being organized with the support of the Ministry of Commerce and Industrial Promotion (SECOFI), the Ministry of Energy, Mining and Quasi-Governmental Industry (SEMIP), the Institute of Electrical Research and the Chamber of the Electronics Industry and Electrical Communications. By virtue of its functions, this centre will represent an appropriate nodal point for the REMLAC System.

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IIE	Institute of Electrical Research.
IMP	Mexican Petroleum Institute.

UAM	Autonomous Metropolitan University.
INAOE	National Institute of Astrophysics, Optics and Electronics.
SECOFI	Ministry of Commerce and Industrial Promotion.
SEMIP	Ministry of Energy, Mining and Quasi-Governmental Industry.
CANIECE	National Chamber of the Electronics Industry and Electrical Communications.

ANNEX II

Places visited

BRAZIL

UNIDO
Special Data Processing Department
Data Processing Technology Centre
Telebras
ABC-XTAL
UNICAMP
ITAUCOM
SID
AEGIS
University of Sao Paulo
Heliodinamica

ARGENTINA

UNIDO
INTI
CITEFA
CENICE
Department of Science and Technology
National Electronics Programme

VENEZUELA

Engineering Institute Foundation
Venezuelan Institute of Scientific Research
CAFADAE
MICROTEL
XYNERTEK